EXHIBIT K

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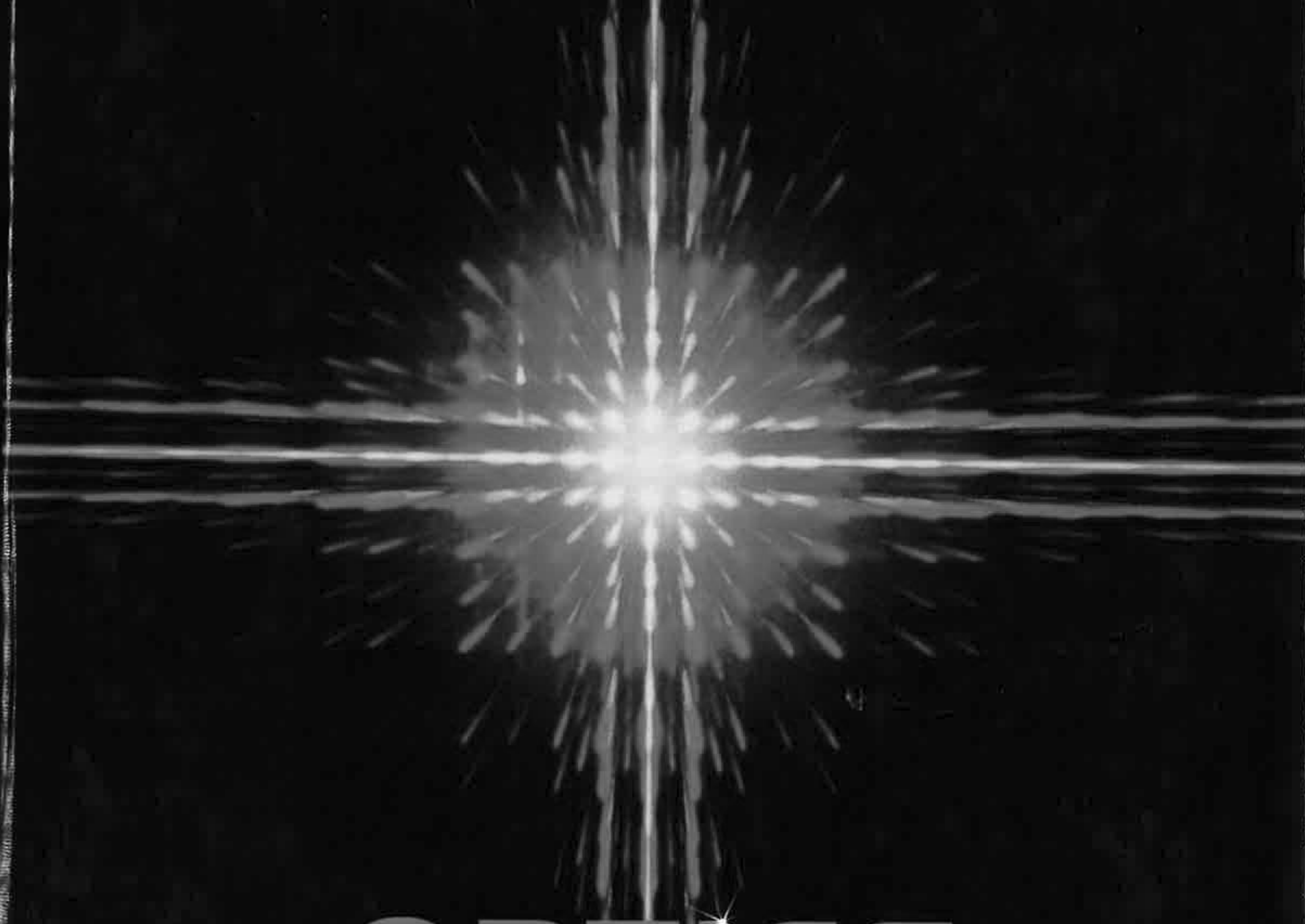

OPTICS

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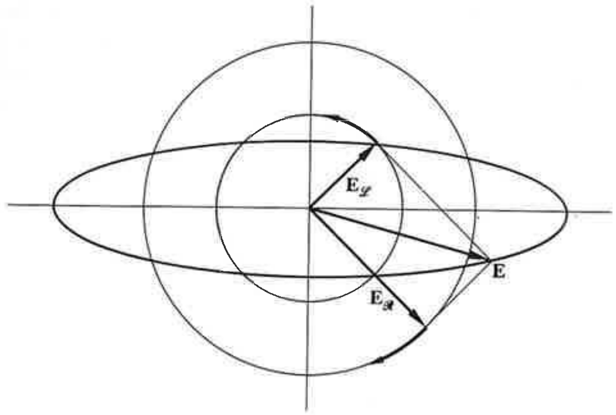

FIGURE 8.8 Elliptical light as the superposition of an $\mathscr{R}$- and $\mathscr{L}$-state.

8.1.4 Natural Light

An ordinary light source consists of a very large number of randomly oriented atomic emitters. Each excited atom radiates a polarized wavetrain for roughly 10^{-8} s. All emissions having the same frequency will combine to form a single resultant polarized wave, which persists for no longer than 10^{-8} s. New wavetrains are constantly emitted, and the overall polarization changes in a completely unpredictable fashion. If these changes take place at so rapid a rate as to render any single resultant polarization state indiscernible, the wave is referred to as **natural light**. It is also known as *unpolarized light*, but this is a misnomer, since in actuality the light is composed of a rapidly varying succession of the different polarization states. *Randomly polarized* is probably a better way to speak of it.

We can mathematically represent natural light in terms of two arbitrary, *incoherent*, orthogonal, linearly polarized waves of equal amplitude (i.e., waves for which the relative phase difference varies rapidly and randomly).

Keep in mind that an idealized monochromatic plane wave must be depicted as an infinite wavetrain. If this disturbance is resolved into two orthogonal components perpendicular to the direction of propagation, they, in turn, must have the same frequency, be infinite in extent, and therefore be mutually coherent (i.e., $\varepsilon =$ constant). In other words, ***a perfectly monochromatic plane wave is always polarized***. In fact, Eqs. (8.1) and (8.2) are just the Cartesian components of a transverse ($E_z = 0$) harmonic plane wave.

Whether natural in origin or artificial, light is generally neither completely polarized nor completely unpolarized; both cases are extremes. More often, the electric-field vector varies in a way that is neither totally regular nor totally irregular, and such an optical disturbance is **partially polarized**. One useful way of describing this behavior is to envision it as the result of the superposition of specific amounts of natural and polarized light.

8.1.5 Angular Momentum and the Photon Picture

We have already seen that an electromagnetic wave impinging on an object can impart both energy and linear momentum to that body. Moreover, if the incident plane wave is circularly polarized, we can expect electrons within the material to be set into circular motion in response to the force generated by the rotating **E**-field. Alternatively, we might picture the field as being composed of two orthogonal $\mathscr{P}$-states that are 90° out-of-phase. These simultaneously drive the electron in two perpendicular directions with a $\pi/2$ phase difference. The resulting motion is again circular. In effect, the torque exerted by the **B**-field averages to zero over an orbit, and the **E**-field drives the electron with an angular velocity ω equal to the frequency of the electromagnetic wave. Angular momentum will thus be imparted by the wave to the substance in which the electrons are imbedded and to which they are bound. We can treat the problem rather simply without actually going into the details of the dynamics. The power delivered to the system is the energy transferred per unit time, $d\mathscr{E}/dt$. Furthermore, the power generated by a torque Γ acting on a rotating body is just $\omega\Gamma$ (which is analogous to vF for linear motion), so

$$\frac{d\mathscr{E}}{dt} = \omega\Gamma \tag{8.20}$$

Since the torque is equal to the time rate-of-change of the angular momentum L, it follows that on the average

$$\frac{d\mathscr{E}}{dt} = \omega\frac{dL}{dt} \tag{8.21}$$

A charge that absorbs a quantity of energy $\mathscr{E}$ from the incident circular wave will simultaneously absorb an amount of angular momentum L such that

$$L = \frac{\mathscr{E}}{\omega} \tag{8.22}$$